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(54) Title of the Invention: Disk Cache Device

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**1. Title of the Invention**

**Disk Cache Device**

**2. Claims**

1. A disk cache device, comprising a magnetic disk, a cache memory, and a controller for controlling said magnetic disk and cache memory, wherein said disk cache device is characterized by the fact that said controller determines whether or not said cache memory contains data for which an access request has been received from a host computer, actuates the spindle motor of said magnetic disk only when [said data] are not present in said cache memory, and again stops said spindle motor after access to said magnetic disk has been completed.
2. A disk cache device as defined in Claim 1, characterized by the fact that said controller stops the operation of the spindle motor of said magnetic disk when said cache memory contains data for which an access request has been received from said host computer.
3. A disk cache device as defined in Claim 1 or 2, wherein said spindle motor of said magnetic disk is not switched between operation and stoppage when the hit rate is lower than a separately determined value.
4. A disk cache device as defined in Claim 2, wherein said controller actuates said spindle motor of said magnetic disk when data for which an access request has been received from said host computer are not present in said cache memory.

**3. Detailed Description of the Invention**

***Field of Industrial Utilization***

The present invention relates to a disk device having a cache memory.

As described in the conventional examples cited in the DRPO 40C product specifications for hard disks manufactured by Alps Electric, commands for placing a magnetic disk in a low power consumption mode (and thus to lower the power consumption of the magnetic disk device) have in the past been issued by a host computer. An alternative has been to allow a magnetic disk itself to automatically switch to a low power consumption mode when no commands have been received by the magnetic disk over a predetermined period of time.

*Problems Which the Invention Is Intended to Solve*

With the aforementioned prior art, no consideration was given to the power consumption of a magnetic disk having a disk cache, and no provisions were made for reducing the power consumption of such magnetic disks. For a magnetic disk having a disk cache, however, a request for accessing the disk from the host computer (even when such a request is made) does not require accessing the disk while the corresponding data are held in the cache memory, that is, while a hit is made, and the power consumed by the disk in this period is wasted. It is therefore desirable to place the disk in a low power consumption mode when the requested data have been hit, even if an access request has been received from the host.

It is, however, impossible for the host computer to determine whether the requested data have been hit or missed, so the host computer cannot place the disk in a low power consumption mode when the requested data are hit, and electric power is wasted.

An object of the present invention is to lower the power consumption of a magnetic disk device having a disk cache.

*Means Used to Solve the Above-Mentioned Problems*

Aimed at attaining the stated objective, the present invention involves actuating a magnetic disk only when the cache memory does not contain the data requested by the host (when a miss occurs) and the magnetic disk is accessed, and placing the magnetic disk in a low power consumption mode under all other conditions. Specifically, the magnetic disk is

switched between different modes of operation by a magnetic disk controller independently of the host computer.

As used herein, the term "low power consumption mode of a magnetic disk" refers either to a mode in which power supply to ENDEC, an R/W circuit, or another signal processing circuit has been cut and the spindle motor of the disk stopped, or to a mode in which power supply to a signal processing circuit has been cut, but the spindle motor continues to operate.

### *Effect of the Invention*

Because the magnetic disk controller controls the cache memory, it is clear whether or not the data requested by the host have been hit or missed. The fact that the magnetic disk controller switches the magnetic disk between an operating mode and a low power consumption mode makes it possible to place the magnetic disk in the low power consumption mode when the data have been hit.

### **Practical Examples**

A practical example of the present invention will now be described with reference to figures.

Figure 2 is a block diagram of the hardware pertaining to a practical example of the present invention.

In Figure 2, 201 is a host computer, 202 a host interface controller, 203 a disk/cache memory controller, and 204 a cache memory.

An encoder/decoder data separator (205), a waveform shaping circuit (206), and an R/W circuit (207) are components of a signal processing circuit; the disk/cache memory controller 203 can control the feeding and cutting of power via power save control 2.

210 is a spindle motor drive. The disk/cache memory controller 203 can control the manner in which a spindle motor 211 is switched on and off via the spindle motor drive 210 by means of power save control 1.

A processing run performed in accordance with the present invention will now be described with reference to Figure 1. The processing starts with step 11. In step 12, the disk/cache memory controller 203 switches off the spindle motor 211 using power save control 2. In conjunction with this, the power supply of the signal processing circuit is switched off using power save control 1.

Next, in step 13, the disk/cache memory controller 203 is held in a standby mode of low power consumption until a request is received from the host. As referred to herein, the low power consumption mode may, for example, involve stopping the input of clock [pulses] to the disk/cache memory controller, reducing the loss of electric power.

In step 14, in which a request is received from the host, the disk/cache memory controller 203 cancels the low power consumption mode.

Next, in step 15, the disk/cache memory controller 203 determines whether or not the data requested by the host have been hit or missed. In the case of a hit, data are exchanged between the cache memory and the host during step 16. If a miss occurred during step 15, the spindle motor 211 of the magnetic disk is switched on during step 17, and power is fed to the signal processing circuit of the magnetic disk. In step 18, data are exchanged between the host and the magnetic disk via the cache memory 204, and in step 19 the spindle motor 211 of the magnetic disk is switched off again, and power is cut off from the signal processing circuit of the magnetic disk.

Another practical example will now be described with reference to Figure 3.

This practical example envisages preventing the spindle motor from being switched on and off with high frequency when the hit rate is low.

Steps 301 through 309 are the same as steps 11 through 19 in Figure 1. In this practical example, the disk/cache memory controller 203 determines in step 310 whether the hit rate has until now been high or low when the request from the host has failed to retrieve data during step 305. Values serving as high and low reference levels should be separately preset, and the current hit rate compared with these numerical values.

If the hit rate is high, the same processing as in the practical example above will be performed. If the hit rate is low, the spindle motor 211 of the disk is switched on (if it has been switched off) in step 311. Next, in step 312, data are exchanged between the disk and the host via a cache memory 204.

### **Merits of the Invention**

Because the present invention involves operating the spindle motor of a magnetic disk only in the case of a miss, the loss of electric power is reduced, and power consumption can be lowered.

Another advantage is that because the spindle motor always operates when the hit rate is low, it is possible to reduce the time delay caused by the switching on and off of the spindle motor.

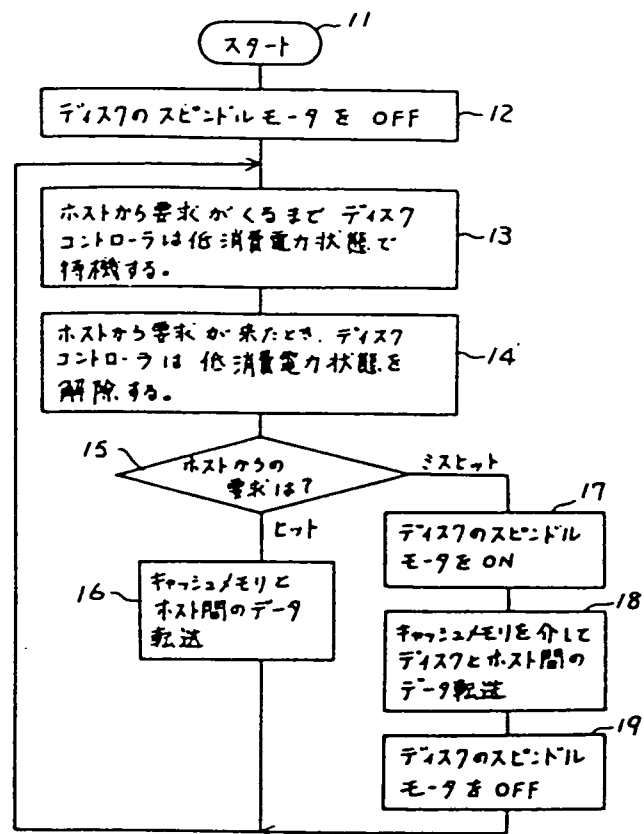
### **4. Brief Description of the Drawings**

Figure 1 is a flow chart showing the processing performed in accordance with a practical example of the present invention, Figure 2 is a block diagram of the hardware [for carrying out the processing shown] in Figure 1, and Figure 3 is a flow chart showing the processing performed in accordance with another practical example of the present invention.

### **Key**

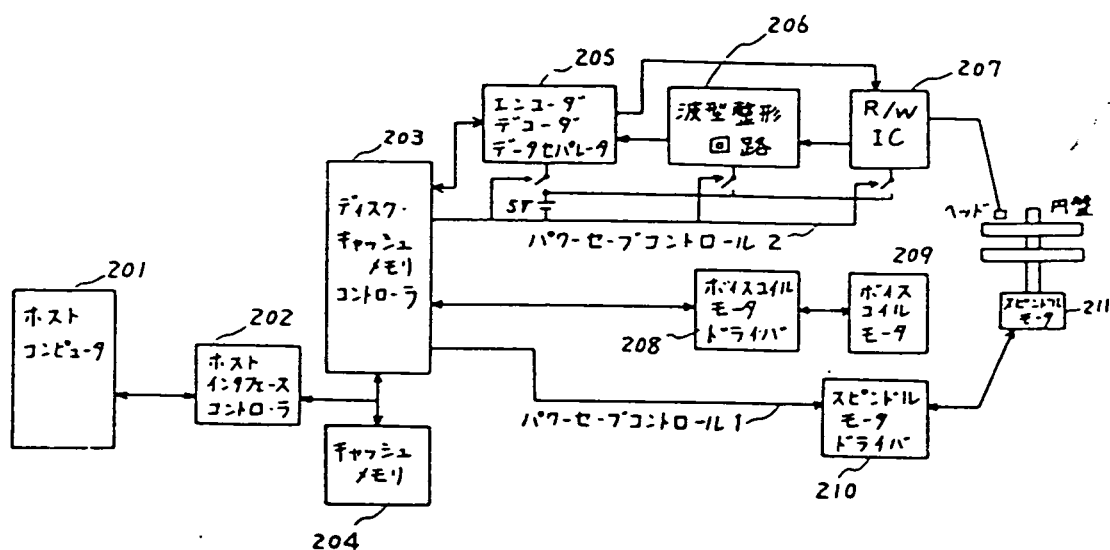
203: disk/cache memory controller, 204: cache memory, 205: encoder/decoder data separator, 206: waveform shaping circuit, 207: R/W IC, 211: spindle motor

Figure 1



Key to Figure 1

- 11 Start
- 12 Disk spindle motor off
- 13 Disk controller maintains standby mode of low power consumption until request received from host
- 14 Disk controller cancels low power consumption mode when request received from host
- 15 Request from host?
- (Below 15) Hit
- 16 Data exchange between cache memory and host
- (Above 17) Miss
- 17 Disk spindle motor on
- 18 Data exchanged between disk and host via cache memory
- 19 Disk spindle motor off



### Key to Figure 2

- |     |                                |
|-----|--------------------------------|
| 201 | Host computer                  |
| 202 | Host interface controller      |
| 203 | Disk/cache memory controller   |
| 204 | Cache memory                   |
| 205 | Encoder decoder data separator |
| 206 | Waveform shaping circuit       |

(Between 203  
and 207)

**[Power save control 2**

(Above 211  
to the left)

## Head

(Above 211  
to the right)

## Disk

- |     |                         |
|-----|-------------------------|
| 208 | Voice coil motor driver |
| 209 | Voice coil motor        |

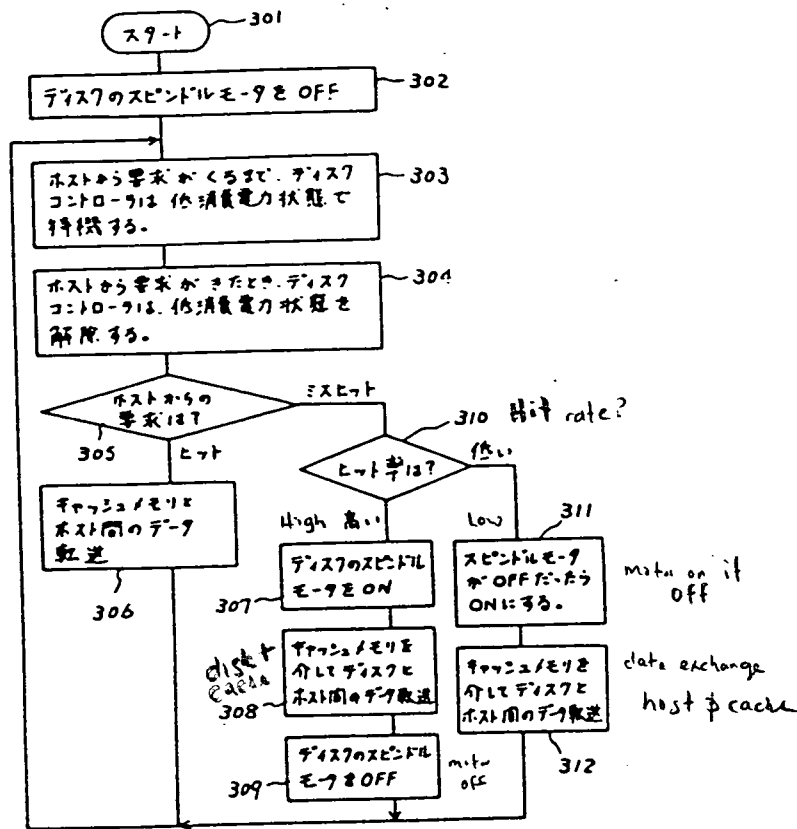
(To the left  
of 210)

## Power save control 1

- |     |                      |
|-----|----------------------|
| 210 | Spindle motor driver |
| 211 | Spindle motor        |



Figure 3



Key to Figure 3

- 301 Start
- 302 Disk spindle motor off
- 303 Disk controller maintains standby mode of low power consumption until request received from host
- 304 Disk controller cancels low power consumption mode when request received from host
- 305 Request from host?
- (Below 305) Hit
- 306 Data exchange between cache memory and host
- (Above 310, to the right of 305) Miss
- 310 Hit rate?
- (Above 307) High
- 307 Disk spindle motor on
- 308 Data exchanged between disk and host via cache memory
- 309 Disk spindle motor off
- (Above 311, to the right of 310) Low
- 311 Spindle motor switched on if previously off
- 312 Data exchanged between disk and host via cache memory

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識別記号

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⑭ 発明の名称 ディスクキャッシュ装置

⑮ 特 願 平2-328844

⑯ 出 願 平2(1990)11月30日

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## 明 細 書

## 1. 発明の名称

ディスクキャッシュ装置

## 2. 特許請求の範囲

1. 磁気ディスクと、キャッシュメモリと、前記磁気ディスクおよび前記キャッシュメモリを制御するコントローラとを備えたディスクキャッシュ装置において、

前記コントローラは、ホストコンピュータからアクセス要求があったデータが前記キャッシュメモリに存在するか否かを判別し、前記キャッシュメモリに存在しない場合のみ、前記磁気ディスクのスピンダルモータを動作させ、前記磁気ディスクへのアクセス終了後に、再び、前記スピンダルモータを停止させることを特徴とするディスクキャッシュ装置。

2. 請求項1において、前記コントローラは、前記ホストコンピュータからアクセス要求があったデータが前記キャッシュメモリに存在する場合は、前記磁気ディスクのスピンダルモータの

動作を止めることを特徴とするディスクキャッシュ装置。

3. 請求項1または2において、ヒット率が別途定めた値よりも低い場合は、前記磁気ディスクの前記スピンダルモータの動作、停止の切り換えをしないディスクキャッシュ装置。

4. 請求項2において、前記コントローラは、前記ホストコンピュータからアクセス要求があったデータが前記キャッシュメモリに存在しない場合に、前記磁気ディスクの前記スピンダルモータを動作させるディスクキャッシュ装置。

## 3. 発明の詳細な説明

## 〔産業上の利用分野〕

本発明は、キャッシュメモリをもつディスク装置に関する。

## 〔従来の技術〕

従来、アルプス電気製ハードディスクDRPO 40C製品仕様書に記載のように磁気ディスク装置の低消費電力化についてはこの公知例に記載のように、磁気ディスクを低消費電力状態にするコ

めて、電力の浪費をおさえることである。

ホストから要求が来たときステップ14で、ディスク・キャッシュメモリコントローラ203は低消費電力状態を解除する。

次に、ステップ15で、ディスク・キャッシュメモリコントローラ203は、ホストから要求のあったデータがヒットしたかミスヒットしたかを判定する。ヒットしたときには、ステップ16でキャッシュメモリとホスト間のデータ転送を行う。ステップ15でミスヒットしたときには、ステップ17で、磁気ディスクのスピンダルモータ211をONし、あわせて、磁気ディスク中の信号処理回路の電源をONする。そして、ステップ18で、キャッシュメモリ204を介して磁気ディスクとホスト間のデータ転送を行い、ステップ19で、再び、磁気ディスクのスピンダルモータ211をOFFにし、あわせて磁気ディスク中の信号処理回路の電源をOFFにする。

第3図を用いて、他の一実施例を説明する。

浪費が少なくなり、低消費電力化できる。

また、ヒット率が低い間は、スピンダルモータを常に動作させておくことができるので、スピンダルモータのON・OFFによる時間の遅れを軽減することができる。

#### 4. 図面の簡単な説明

第1図は本発明の一実施例の処理を示すフローチャート、第2図は第1図のハードのブロック図、第3図は本発明の他の一実施例の処理を示すフローチャートである。

#### 符号の説明

203…ディスク・キャッシュメモリコントローラ、204…キャッシュメモリ、205…エンコーダ・デコーダデータセパレータ、206…波形整形回路、207…R/W IC、211…スピンダルモータ。

ータのON、OFFを所望に行わないようにするものである。

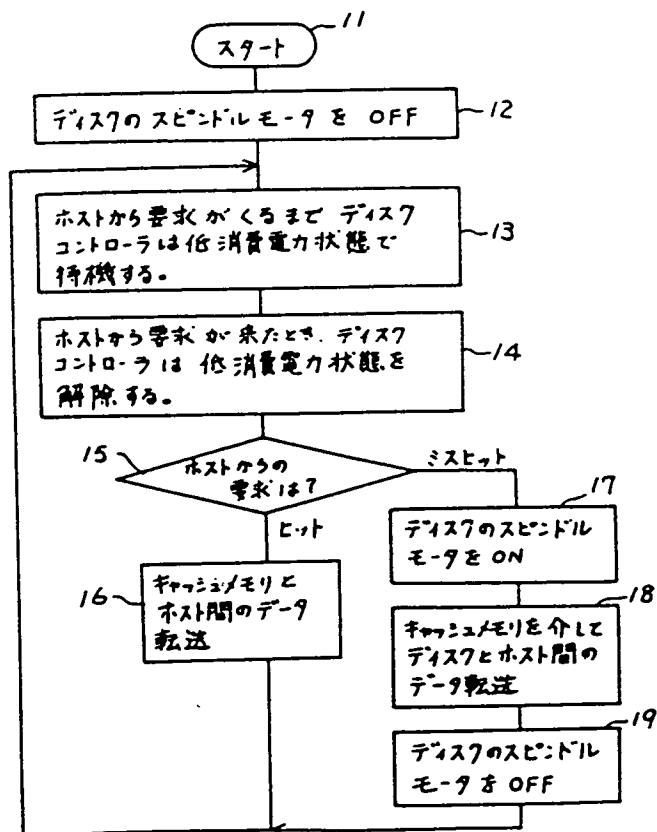
ステップ301～ステップ309までは、第1図のステップ11～ステップ19までと同じである。本実施例では、ステップ305でホストからの要求がミスヒットしたときディスク・キャッシュメモリコントローラ203はステップ310で、現在までのヒット率が高いか低いかを判定する。高いか低いかの基準となる値は別に決めておき、この数値と現在のヒット率とを比べればよい。

ヒット率が高いときは、前に述べた実施例と同じ処理を行う。ヒット率が低いときは、ステップ311でディスクのスピンダルモータ211がOFFのときはONにする。次に、ステップ312でキャッシュメモリ204を介してディスクとホスト間のデータ転送を行う。

#### [ 発明の効果 ]

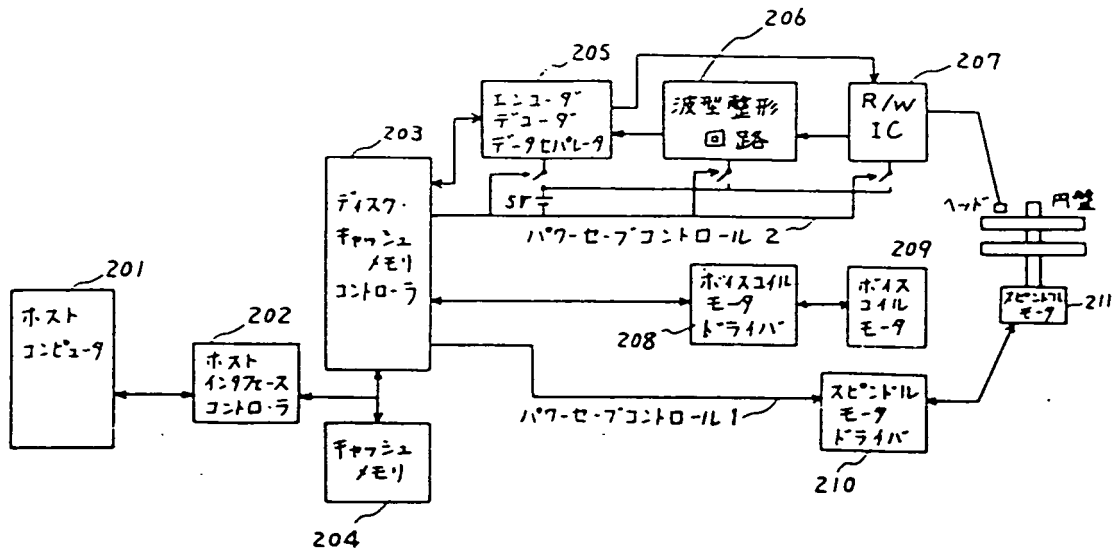
本発明によれば、ミスヒット時のみ磁気ディスクのスピンダルモータを動作させるので、電力の

第1図



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## 第 2 図



## 第 3 図

